generated as a function of applied voltage to the upper limit of mass filter **40** is approximately linear. Thus, voltage required to provide a desired m/z filter **40** is easily calculated. The ability to change potential on filter plate **40** to provide a desired mass filter range allows for quick adjustments to the instrument based on sample properties, providing for dynamic low-m/z filtering in an automated process. Height of the barrier or potential can be easily controlled by adjusting the voltage applied to filter plate **40**. The energy barrier potential exploits the ion mobility and the characteristic kinetic energy spread of lower-m/z source ions allowing selection of a particular mass (m/z) cut-off (mass filter) for the filter plate **40**.

When a positive DC potential is applied to filter plate **40** of ion funnel **10**, ion velocity is defined by the balance of the drag force from the gas flow and the force from the applied electric field. The free ion motion model that assumes conservation of the sum of ion kinetic and potential energies is not applicable under the conditions of a high buffer gas pressure. Instead, one can apply a drift ion motion model, e.g., as used in ion mobility studies, where ion drift velocity (V_{drift}) is defined by equation [1]:

$$V_{drift}=KE \tag{1}$$

where V_{drift} is the ion drift velocity, K is the mobility coefficient, and E is the DC electric field. In order to pass the DC electric field barrier generated at filter plate **40**, the drift velocity of the ions should be smaller than the gas flow velocity. The mobility coefficient (K) can be further expressed via the collision cross section (a), as defined by equation [2]:

$$K=\frac{3ze}{16n\sigma}\left(\frac{2\pi}{m_r k_b T}\right)^{\frac{1}{2}} \tag{2}$$

where "n" is the buffer gas number density, "k_b" is the Boltzmann constant, "T" is the temperature, "ze" is the ion charge, and "m_r" is the reduced mass of the buffer gas and ion.

The linear dependence of the low m/z cut off as a function of the applied filter plate **40** voltage (described in reference to FIG. **4***c* herein) can be attributed to the mobility dependence on the ion size. Equation [2] shows that ion drift velocity is inversely proportional to the ion cross section (a). In a linear approximation, the cross section (σ) can be roughly evaluated via the ion mass (m), where, in equation [3]:

$$\sigma(m)\sim(\sigma_0+c_1 m) \tag{3}$$

where σ_0 is the initial cross section, c_1 is a first order approximation constant, and m is the ion mass. This correlation is revealed in ion mobility/MS experiments that show ion drift times increasing linearly with m/z within a specific charge state "z". For example, substituting $\sigma(m)$ of equation [3] into equation [2], one obtains a linear dependence for low-mass (m/z) cut off as a function of the DC field at exit **65**, which in turn is proportional to the DC offset. A linear fit to experimental data (e.g., as shown in FIG. **4***c*) yields the relationship shown in equation [4]:

$$\sigma=104\ \text{Å}^2+0.09*(m/z) \tag{4}$$

The term $\sigma=104$ Å^2 can be interpreted as the cross section due to long-term, e.g. ion-dipole, interactions. The second term, 0.09*(m/z), represents the hard-core cross section that is proportional to ion size. The model of gas flow-electric field competition gives the correct order of magnitude estimation for the behavior observed experimentally. Ion species blocked by the DC field at exit **65** are accumulated in the effective potential well at exit **65**, wherein low m/z instability (elimination) is caused by radial ejection due to ion cloud expansion.

FIGS. **2***a*-**2***b* illustrate two configurations for rear section **45** (**45***a* and **45***b*) of ion funnel **10**, according to two embodiments of the invention. FIG. **2***a* illustrates a first configuration for rear section **45** (i.e., **45***a*) of ion funnel **10** for effecting low-m/z filtering, showing a more detailed view of filtering plate **40**. Filter plate **40** has a conductance limiting aperture **65** electrically isolated from the RF and DC gradient of funnel **10**. As described herein, a voltage applied to filter plate **40** produces an energy barrier, turning plate **40** into a low-mass filter **40**. Filter **40** is biased by an independent DC power supply **62** with a low-pass electrical filter **82**, which is a simple RC circuit made with, e.g., a 240 kΩ resistor and natural capacitance of the co-axial cable coupled to the ground of power supply **62**. Low-pass electrical filter **82** removes a majority of induced current generated by the RF of funnel **10**. FIG. **2***b* illustrates a second configuration for rear section **45** (i.e., **45***b*) that permits detection and measurement of ion currents after filter **40**. In the figure, a second DC-only electrode **42** is positioned in ion funnel **10** immediately after mass filter **40**. An 83 lines per inch copper mesh **44** (Buckbee-Mears, St. Paul, Minn., USA) is placed across the 2 mm diameter exit aperture **67** of second plate **42** by machining an 8 mm diameter, 0.25 mm deep counter bore hole **67** at the center of plate **42** and adhering mesh **44** with a conductive, silver epoxy (ITW Chemtronics, Kennesaw, Ga.). In addition, low-pass electrical filter **82** is used to remove induced current caused by RF of funnel **10**. Mesh plate **44** may be biased with a DC power supply **63** by "floating" the ground of picoammeter **64** (e.g., a Keithley Model 6485, Cleveland, Ohio) used to detect ion current impacting mesh **44**.

In a typical operation, ion funnel **10** is operated, e.g., by applying an RF of 500 kHz at 90 V peak-to-peak (V_{p-p}), but is not limited thereto. At the stated RF value, DC voltage applied to ion funnel **10** generates a constant gradient of about 200 V at the inlet **55** down to 5 V at the outlet **65** or **67**, but again is not limited thereto. In the instant operation, pressure in funnel **10** is about 1.9 Torr, but is not limited thereto.

The following examples are intended to promote a further understanding of the present invention.

EXAMPLES

Example 1 describes tests showing ability of the conductance limiting electrode to perform selective low-mass filtering as a low m/z filter. Example 2 describes tests relating m/z cut-off of filter **40** to potential applied to filter **40** necessary to achieve filtering of low m/z ions. Example 3 describes DC voltage distribution effects observed in the region near the aperture of filter plate **40** as a function of radial distance at an applied filter voltage of 15 V. Example 4 details effects associated ion funnel RF voltages on attenuation of higher-massed peaks above m/z 500 when using mass filter **40**. Example 5 details use and evaluation of the low-mass filter **40** for a liquid chromatography-mass spectrometry (LC-MS) analysis of a Bovine Serum Albumin (BSA) tryptic digest.

Example 1

Example 1 describes tests showing ability of the conductance limiting electrode **40** of ion funnel **10** to perform selective low-mass filtering, e.g., as a low m/z filter **40**.